CANADA

COLLATERAL ANALYSIS AND VERIFICATION OF BIOLOGICAL AND TOXIN RESEARCH IN IRAQ

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PREFACE

The Gulf War brought to the surface the serious concern that Iraq might have developed, produced and stockpiled biological and toxin weapons. This matter is now the subject of investigation under United Nations Security Council Resolution 687. This paper does not directly address this matter, although it may be of indirect interest to UN investigators.

This paper uses "collateral analysis" to identify from the public literature the types of biological research that have been conducted in Iraq and published. This can accomplish the following:

- identify specific areas of published research activity;
- identify institutions and scientists associated with such published research activity;
- identify the absence of published research activity in specific areas of endeavour.

Such collateral analysis can give indications of a country's technological base. It must be emphasized that this report does not suggest that the work of the institutes and authors cited is in any way associated with biological warfare programs. This paper simply collates publicly-available documentation as published by the institutes and authors concerned, and it draws no conclusions on the basis of that information.

One thing must be clear from the outset: collateral analysis cannot be expected to reveal activities that are deliberately concealed. It can, however, assist in the formulation of questions about the capabilities and activities of various facilities, in conjunction with other sources of information.

The purpose of this document is to promote discussion, and the views expressed herein do not necessarily reflect those of the Canadian Government.

ACKNOWLEDGEMENT

External Affairs and International Trade Canada wishes to acknowledge the work performed under contract by Brac Scientific Consulting, in collaboration with the Verification Research Unit of this Department.

PRINCIPAL FINDINGS AND CONCLUSIONS

- Various computerized databases, containing over 29 million records of scientific research from over 130 countries during the period 1969-1991, were accessed using key words related to biological and toxin research.

- Publications titles thus found were reviewed to avoid duplication and ensure relevance.

- The records of the published research were analyzed in terms of:
  - sites of research;
  - patterns of the publications over time;
  - authors; and
  - apparent nature of the research.

- For the period 1969-1991, there were 10,100 publications identified from Iraq in the various databases (including duplicate reporting).

- A unique set of 991 Iraqi publications was established using key words, and this formed the basis of the subsequent analysis. These publication titles appear in the Annexes to this paper.

- The main laboratories and institutes publishing on biological and toxin matters were identified as:
    - the Biological Research Centre, Baghdad;
    - the Nuclear Research Institute, Tuwaitha;
    - the College of Medicine, University of Baghdad;
    - the University of Basrah;
    - the University of Mosul;
    - the University of Sulaymaniyah;
    - the Department of Pharmacology, University of Baghdad
    - the University of Salahaddin;
    - the Genetic Engineering and Biotechnology Research Centre, Baghdad; and
    - the State Company for Drug Industries, Samarra.

- The government laboratories appear to be clearly superior to the university laboratories.

- The main sites of research were the Biological Research Centre of the Scientific Research Council, in Baghdad; and the Nuclear Research Institute of the Atomic Energy Commission, in Tuwaitha. Also notable for the advanced level of research was the Genetic Engineering and Biotechnology Research Centre of the Scientific Research Council, in Baghdad, although it published a much smaller output of papers.

- It appears that some of the research conducted at the research laboratory of the State Company for Drug Industries, located in Samarra, may have involved cooperation with East German researchers before 1983.

- *Bacillus anthracis* (the bacterium which causes anthrax) and *Clostridium botulinum* (the source of botulinum neurotoxin which causes botulism) were each the subject of only one publication over the period 1969-1991. In the case of anthrax, this is surprising because it is a potential health hazard in the region.

- Other strains of microorganisms were obtained by Iraqi researchers, but there have been no research results published on them. These include the bacterium *Francisella tularensis*, which causes tularemia; and the West Nile virus.

- The American Type Culture Collection and the U.S. Centres for Disease Control are reported to have shipped materials to researchers in Iraq.

- No publications at all were found from Salman Pak, although it was said by Iraqi officials to be conducting research on food contamination.

1.0 INTRODUCTION

Security Council Resolution 687, dated 3 April 1991, requires that Iraq accept destruction, removal or rendering harmless, under international supervision, of all chemical and biological weapons and all stocks of agents and all related subsystems and components and all research, development, support and manufacturing facilities.

On 18 April 1991, the Iraqi Government advised the United Nations Secretary-General that "Iraq does not possess any biological weapons or related items...."

On 14 August 1991, following an inspection initiated by the UN Special Commission of the undeclared facility at Salman Pak, the United Nations issued a press release from which the following points are drawn:

- "On the first day, Iraq declared that biological research activities for military purposes were initiated in Iraq in mid-1986 at the Salman site. Research was stated to be undertaken on *Clostridium botulinum*, *Clostridium perfingens*, and *Bacillus anthracis.* Military research was later explained to comprise research which could be used for both defensive and offensive purposes."
- "At Salman site, the team discovered a capability to research, produce, test and store biological warfare agents. Fermentation, production, aerosol testing and storage existed at that site."
- "Iraq admitted to have worked on the following biological warfare agents: anthrax and botulinum toxin."

- "...Iraq handed over a collection of biological materials which could be developed as biological warfare agents. This material included brucellosis and tularemia." (sic)

The Biological and Toxin Weapons Convention (BTWC), which Iraq had signed in 1972 but not ratified until imposed by Security Council Resolution 687, forbids the development, production and stockpiling of such weapons, as is indicated from the enclosed box. By signing the Convention in 1972, Iraq assumed an obligation under international law not to take any action contrary to the purpose and provisions of the Convention, even though it had yet to ratify the Convention .

Article I

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

(1) Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
(2) Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

This is the recent background against which this analysis was conducted of Iraqi publications on the subject of biological and toxin research. The term "collateral analysis" has been used to describe a method of information gathering that involves the collection and systematic examination of publicly-available scientific, technical and other information. It makes no judgement as to the purpose of the research. This analysis may provide an initial picture of a country's technological base and of its capacity to move in a variety of directions, some of which may be of concern. Similarly, a lack of publication in certain areas of endeavour, when coupled with other sources of information, could raise certain questions. It must be added, however, that collateral analysis cannot be expected to reveal activities that are deliberately concealed.

This study had three objectives:

1) to identify specific areas of published research activity;
2) to identify institutions and scientists associated with such published research activity; and
3) to identify the absence of published research activity in specific areas of endeavour.

2.0 STUDY METHODOLOGY

A major part of this study depended upon the gathering of information available in the open scientific literature, specifically computerized databases. Therefore, the sources and quality of the information played an important role in determining the usefulness of collateral analysis. The contractor has direct access to relevant databases to make literature searches and can load the results directly to his computer for analysis. Table 1 lists five databases that have been found to provide particularly useful coverage of biological, biochemical and medical research. Together, these databases contain over 29 million records of scientific research from over 130 countries. Accordingly, they were the primary sources of information used in this study of Iraqi research. The following sections will describe the databases and their breadth of coverage.

Table 1. Major Scientific Databases

DATABASE	**COVERAGE**	**RECORDS**
BIOSIS Previews	1969-present	7,196,209
Embase	1974-present	4,311,401
Medline	1966-present	6,506,421
CAB Abstracts	1972-present	2,451,111
CS Search	1969-present	9,411,231

2.1 BIOSIS Previews

BIOSIS Previews contains citations from Biological Abstracts (BA); Biological Abstracts/RRM (Reports, Reviews, Meetings [BA/RRM]); and BioResearch Index (BioI), which are the major publications of BIOSIS. Together, these publications constitute the major English-language service providing comprehensive worldwide coverage of research in the biological and biomedical sciences. Biological Abstracts includes approximately 280,000 accounts of original research yearly from nearly 9,000 primary journal and monograph titles. Biological Abstracts/RRM includes an additional 260,000 citations a year drawn from meeting abstracts, reviews, books, notes, letters, selected institutional and government reports, and research communications. U.S. patents are included from 1986 through 1989. The time period covered by BIOSIS Previews is 1969 to the present. The subject coverage in this database includes all life science subjects, including but not limited to the following: Agriculture, Anatomy, Bacteriology, Behavioral Sciences, Biochemistry, Bioengineering, Biophysics, Biotechnology, Botany, Cell Biology, Clinical Medicine, Environmental Biology, Experimental Medicine, Genetics, Immunology, Microbiology, Occupational Health, Parasitology, Pathology, Pharmacology, Physiology, Public Health, Radiation Biology, Systematic Biology, Toxicology, Toxin Research, Veterinary Science, Virology, Zoology.
The material scanned for BIOSIS Previews includes the following: approximately 9,000 primary journal and monograph titles, books, reviews, technical reports, meetings and meeting abstracts, notes, letters, annual reviews, U.S. patents from 1986 through 1989, bibliographies, guides, and research communications.

2.2 Embase

Embase (Excerpta Medica) is a comprehensive index of the world's literature on human medicine and related disciplines. About 350,000 records are added annually, over 60% of which contain abstracts. All journal articles are added to the database within 30 days after receipt of the journal, and all records appear on-line with complete indexing.
Subject coverage includes Adverse Drug Reactions, AIDS, Anaesthesiology, Bacteriology, Biochemistry, Bioengineering, Cancer, Cardiovascular Disease, Endocrinology, Environmental Health, Forensic Science, Genetics, Gene Technology, Health Economics, Hematology, Immunology, Industrial Medicine, Infectious Diseases, Internal Medicine, Microbiology, Neurology, Nuclear Medicine, Occupational Health, Parasitology, Pathology, Pharmacology, Physiology, Physiotherapy, Pollution Control, Psychiatry, Public Health, Radiology, Toxicology, Virology.

Embase provides access to periodical articles from more than 2,900 primary journals from over 110 countries. An additional 600 journals are screened for drug articles.
This database provides coverage of research from 1974 to the present.

2.3 CA Search

The CA Search database includes citations to the literature of chemistry and its applications. A significant part of its coverage includes biological chemistry, biotechnology, peptides, toxins and genetic engineering. CA Search is an expanded database which contains the basic bibliographic information appearing in the printed Chemical Abstracts. The subject coverage includes Applied Chemistry, Biochemistry and Biology, Chemical Engineering, Classes of Substances, Macromolecular Chemistry, Organic and Inorganic Chemistry, Physical and Analytical Chemistry, Properties and Reactions.

The following sources are included in CA Search: journal articles, patents, reviews, technical reports, monographs, conference and symposium proceedings, dissertations, and books. Over 10,000 primary journals are abstracted. This includes coverage from over 120 countries. The database is updated two times a week with approximately 17,000 records per update. CA Search covers the time period 1967 to the present.

2.4 CAB Abstracts

CAB Abstracts is a comprehensive file of agricultural and biological information containing all records in the 26 main abstract journals published by Commonwealth Agricultural Bureaux. Over 8,500 journals in 37 different languages are scanned for inclusion, as well as books, reports, theses, conference proceedings, patents, annual reports, and guides. In some instances less accessible literature is abstracted by scientists working in other countries. About 130,000 items are indexed each year. Significant papers are abstracted, while less important works are reported with bibliographic details only. The journals included in CAB Abstracts cover the following subjects: agricultural engineering, animal disease, biotechnology, horticulture, nutrition, veterinary science, entomology, plant pathology, pesticides, fertilizers, weeds, and world agricultural economics.

The material scanned for CAB Abstracts includes the following: scientific journals, books, monographs in series, textbooks, technical reports, published theses, symposia, conference proceedings, review journals, patents, annual reports, bibliographies and guides, and translated journals. The dates covered are 1972 to the present. The database is updated monthly.

2.5 Medline

Medline (Medlars on-line), produced by the U.S. National Library of Medicine, is one of the major sources for biomedical literature materials. Additional materials not published in Index Medicus are included in the Medline database in the areas of population and reproductive biology. Abstracts, which are taken directly from the published articles, are included for over 47% of the records added from 1975 forward. Records added before 1975 do not contain abstracts; records added from 1984 to the present have abstracts for about 59% of the records. Approximately 300,000 records are added per year, of which over 75% represent publications written in the English language.

Subject coverage includes Clinical Medicine, Experimental Medicine, Hospital Literature, Population and Reproductive Biology, Pharmacology, Psychiatry, Environment and Public Health, Veterinary Medicine, Pathology, Anatomy and Physiology, Microbiology and Parasitology, Toxicology. Medline indexes articles from approximately 3,300 journals published in over 70 countries. Dates covered include 1966 to the present.

2.6 Selection Criteria for Iraqi Publications

After Iraqi publications were identified in the major databases, the next step was to use key words to identify certain types of research. These key word are indicators that are considered to have a potential relationship to biological warfare research. It should be clearly noted that the presence of these key words described below does not imply any direct connection between the research and biological weapons programs. Key words are tools with which to identify particular types of research. Only after the patterns, concentrations and possible gaps in the published research are identified can any attempts be made to draw any firm connections between the published research and any potential diversion of biological materials.

abrin
apamin
brevetoxin
batrachotoxin
botulinum toxin
bungarotoxin
conotoxin
curare
diamphotoxin
latrotoxin
mycotoxin
palytoxin
phospholipase
ricin
sarafotoxin
saxitoxin
tetanus toxin
tetrodotoxin
tubocurare

1. Toxin Key Words

Search strategies were used to identify Iraqi research associated with the following topics. The following are key words:

1) Microbiology, virology, bacteriology, infectious diseases;

2) toxins, neurotoxins, (see Box 1 for specific key words);

3) recombinant DNA, gene-cloning, biotechnology;

4) large-scale production, fermentation, bioreactors;

5) vaccine technology, immunology, immunization;

6) aerosol, lyophilization;

tulare?
anthrax
anthracis
brucell?
glanders
pseudomonas
cholera
salmonella
plague
typhoid
typhi
q-fever
influenza
ebola
marburg
lassa
west-nile
congo-crimean
dengue
yellow fever
smallpox

2. Key Words for Biological Agents

angiotensin
atrial natriuretic peptide
bombesin
bradykinin
cholecystokinin
delta sleep-inducing peptide
dynorphin
endorphin
endothelin
enkephalin
gastrin
gonadoliberin
neurotensin
neuropeptide Y
somatostatin
substance P
thyroliberin
vasopressin

3. Bioregulator Key Words

7) specific biological agents, such as bacteria, viruses, rickettsia (see Box 2 for specific key words); and

8) bioregulators (see Box 3 for specific key words).

The approach was taken to use broad terms such as microorganism, virus, bacteria and toxin as well as specific key words. This was done to ensure coverage and not miss any significant area of Iraqi research.

Truncation was used so that minor differences in the ending of a key word would still allow its retrieval. For example, Box 2 gives *tulare?* as a key word. In this case, the question mark allows tularemia or *tularensis* to be selected. *Francisella tularensis* is the bacterium that causes the disease tularemia.

To avoid counting the same work twice, Iraqi publications were selected on the basis of the presence of key words described above. When the publications from all five databases were selected containing these key words, duplicates were identified by comparing bibliographic information, and removed.

The unique set of references were stored in a Pro-Cite bibliographic database. The records of the published research were analyzed in terms of:

1) sites of research;

2) patterns of publications over time;

3) authors of the publications; and

4) apparent nature of the research.

3.0 RESULTS OF THE STUDY

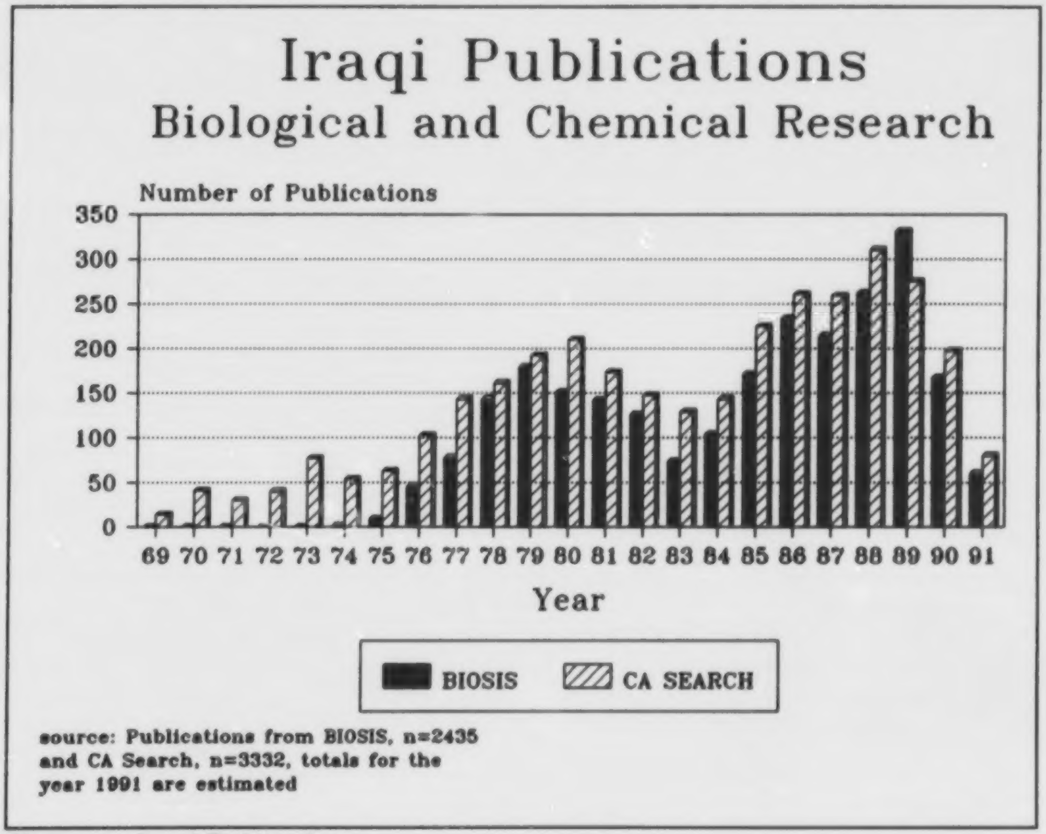
3.1 Iraqi Publications

One of the prime objectives of this study was to develop a baseline of information in order to analyze the trends of published Iraqi biological research. Once a baseline of research in Iraq had been established, questions could be asked about the possible nature of the described research. This report uses the number of scientific publications as a measure of research done. Table 2 gives the total number of publications identified as having research carried out in Iraq. In the time period under consideration, there were **10,100 publications from Iraq.** While thousands of publications would be indicative of a significant level of research, it is important to ask when and where this research was carried out. Of course, the nature of the research is of prime importance. As well, a unique set of publications must be selected on the pertinent topics as described in section 2.6, since the multiple databases may report the same item.

Table 2. Iraqi Publications in Major Scientific Databases

DATABASE	COVERAGE	IRAQI PUBLICATIONS
Biosis Previews	1969-present	2,435
Embase	1974-present	1,361
Medline	1966-present	520
CAB Abstracts	1972-present	2,792
CA Search	1969-present	3,332

This section also describes the time course of the total publications from Iraq. Analysis of publications from Iraq in scientific databases showed marked changes in the number of publications during the period January 1, 1969 to August 10, 1991. Figure 1 shows the pattern of publications in BIOSIS and CA Search. It should be noted that this figure gives the total annual Iraqi publications in each respective database. Thus, in the major biological database BIOSIS, there were no publications from Iraq between 1969 and 1974. Starting in 1975, there was rapid increase in biological publications which peaked in 1979 at over 180 publications. After the peak, the number of publications declined by over 50% by 1983.



source: Publications from BIOSIS, n=2435 and CA Search, n=3332, totals for the year 1991 are estimated

Figure 1. Iraqi Publications

From 1984 to 1989, there was a four-fold increase in the number of all publications from Iraq in the BIOSIS database. As a result, there were 330 publications from Iraq in 1989. After 1989, there was a second decline which was more rapid than the decline in 1980. The output from Iraqi laboratories in 1991 is estimated to be 60 papers. This output is less than the number of papers published in 1977.

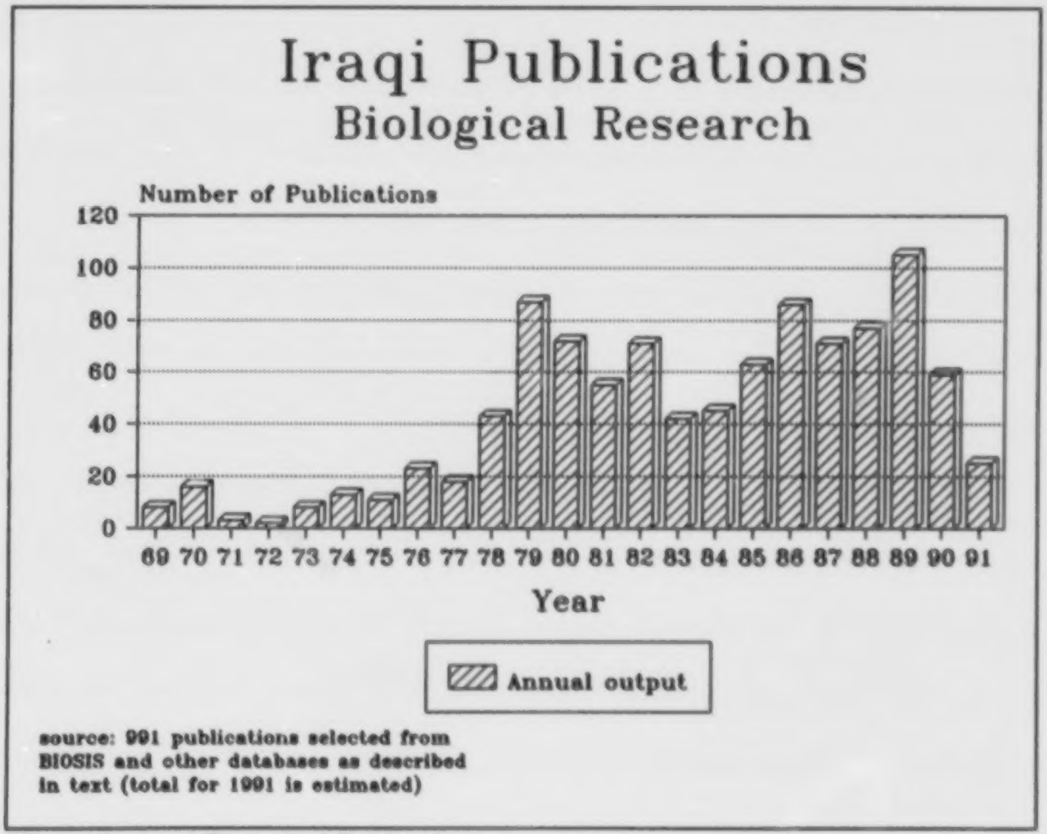
The pattern of Iraqi publications in the CA Search database follows a similar time course as the BIOSIS publications. It should be noted that the database CA Search contains chemical as well as biochemical and biological research. Figure 1 shows that between 1969 and 1974 there were approximately 50 publications per year from Iraq. Starting in 1976, there was a rapid increase in the number of publications until 1980. As in the case of the BIOSIS database, the publications decreased until 1983 after which they showed another rapid increase until 1988. After peaking in 1988, with over 300 publications, the number of Iraqi publications dropped to 80 in 1991. Similar patterns of Iraqi publications in the time period under study were found in the three other major databases used in this study: Embase, Medline and CAB Abstracts.

These results give an overview of **all** Iraqi publications in major scientific databases used in this study. Clearly, there will be research included in these databases that is not at all pertinent to questions that this study is examining. Therefore, it is important to select and survey publications that have been chosen by the key-words that establish more direct relevance to biological and toxin research programs.

3.2 Key Word Selected Iraqi Publications

From all identified Iraqi publications in all databases, research was selected on the basis of key-words described in section 2.6. The objective was to select research containing key words describing research in key subject areas dealing with recombinant DNA, viruses, bacteria, toxins, peptides, bioregulators and other key areas of biological research.

Figure 2 shows the time course of 991 publications from Iraq that were selected on the basis of key-words. These publications formed a unique set of database records which were the basis for this study's analyses. The pattern of published research shows a low output on



source: 991 publications selected from BIOSIS and other databases as described in text (total for 1991 is estimated)

Figure 2. Iraqi Biological Publications

the selected topics until 1977. By 1978, there was a large increase in publications which peaked in 1979. After this year, there was a 50% drop in publications by 1983. After this time, there was an increase to the peak in 1989 when 105 papers were published. After 1989, there was a four-fold decrease in publications to 1991. It should be noted that since this study is inclusive up to August 10, 1991, the total Iraqi publications for 1991 was estimated on the basis of the number of publications in the first seven months of the year.

These large changes in Iraqi biological research raise many questions about the nature of the research. However, in order to provide more detailed analysis, the research contained in the 991 selected publications was further broken down to describe the major laboratories publishing this research. Annex A lists these laboratories as determined by the institutional affiliation that the publications give. The following sections describe the main laboratories and institutes that publish in the scientific literature from Iraq.

3.3 Biological Research Centre, Baghdad

The Biological Research Centre, located in Baghdad, has published 113 publications during the study period on topics in biology. This is a government sponsored research facility that is a designated part of the Scientific Research Council of Iraq. Figure 3 shows the pattern of publications over time from the Biological Research Centre. There were no publications from this Centre before 1977. During 1977 to 1984 there was low but steady output of research, that was followed by a rapid increase in 1985 peaking in 1988. The output from the Biological Research Centre showed a sharp decrease in 1990.

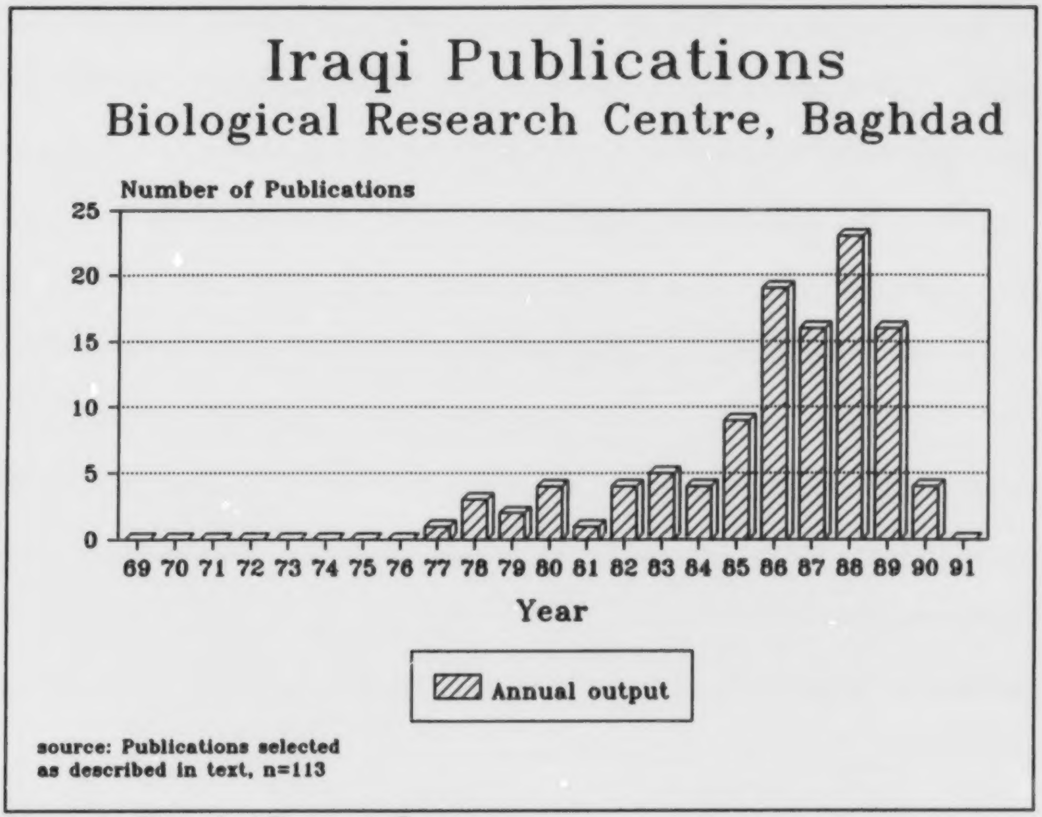


Figure 3. Biological Research Centre

In the first half of 1991, there have been no publications from this Centre. Annex B contains the bibliographic information of the publications from the Biological Research Centre. As well, it contains a list of all 217 scientific personnel listed as authors in the publications. The 9 main authors, who each have 5 or more publications are listed in box 4. All of these authors were active during the peak of publications between 1985 and 1988.

Abdul, Nour B. A.
Al, Rawi E. H.
Al, Shahwani M.F.
Ibrahim, M. A. K.
Jawad, A. L. M.
Jawdat, S. Z.
Jazrawi, S. F.
Mohsen, Z. H.
Salih, F. M.

4. Main Authors

The Biological Research Centre published research on a wide range of biological, biochemical and microbiological subjects. Box 5 lists some of the apparent research priorities as well the microorganisms and toxins that the Centre investigated.

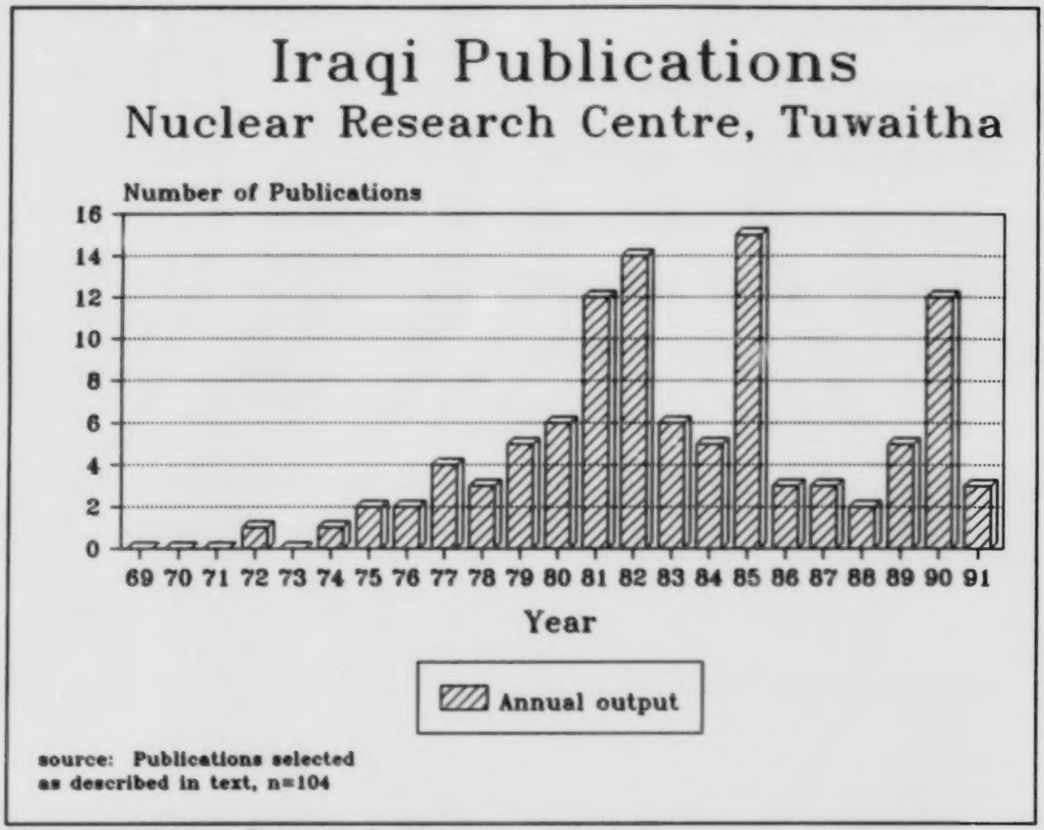
Biological Control (of insects)
Mycotoxins
Pseudomonas aeruginosa
Salmonella typhimurium
Staphylococcus aureus
Bacterial Identification
Antibiotic Sensitivities
Fermentation Products
Single Cell Protein Production

5. Research Priorities

The research facilities at the Biological Research Centre appear to be better than average in comparison to other Iraqi laboratories identified in this study in terms of laboratory equipment and the level of sophistication of the reported research.

3.4 Nuclear Research Institute, Tuwaitha

The Nuclear Research Institute at Tuwaitha is a research facility under the Atomic Energy Commission of Iraq. Tuwaitha is a small town in close proximity to Baghdad. It has been reported that there are research facilities involved in laboratory scale reprocessing of nuclear materials located there as well. The Atomic Energy Commission of Iraq appears to conduct a significant amount of biological research at Tuwaitha. Figure 4 shows the time course of 104 publications from the Nuclear Research Institute. There have been many changes in the output of research publications from this Institute during the time period under investigation. Between 1969 and 1973, there was only one publication which dealt with irradiation of microorganisms. From 1974 to 1979 there was a gradual increase in annual output of research. In 1981 and 1982, there was a 50% increase in publications dealing with



source: Publications selected as described in text, n=104

Figure 4. Nuclear Research Institute

pharmaceutical and pharmacokinetics. In 1983, publications abruptly dropped from the Nuclear Research Institute. This was followed by increases in publications in 1985 and 1990, but a large decrease in 1991.

Box 6 lists the main authors from the Institute. The full list of authors from the Nuclear Research Institute and the list of publications are found in Annex C.

Agha, N. H.
Ahmed, M. S. H.
Al, Hilli A. M.
Al, Hissoni M. H. S.
Al, Janabi M. A. A.
Al-Hakkak, Z. S.
Auda, H.
Hassen, H. A.
Moussa, S. O.
Shafiq, Y. F.

6. Main Authors

Box 7 lists the research priorities observed in the publications from the Nuclear Research Institute. Compared to other Iraqi laboratories examined in this study, especially those affiliated with universities, this appears to be a superior facility. It has modern equipment able to carry out sophisticated research in the areas of radioisotope labelled drugs, synthesis of peptides and radiation biology.

- Bioregulators
- Biological Control (of insects)
- Biotechnology
- Diagnostic Drugs
- Pharmacokinetics
- Peptides and Amino Acids
- Radiation Biology
- Radiopharmaceutical

7. Research Priorities

3.5 College of Medicine, University of Baghdad

The College of Medicine is affiliated with the University of Baghdad. It published 84 papers in the time period under study. Figure 5 shows the time course of the publication output. Between 1969 and 1978, there were less than 2 papers published on average per year. Starting in 1980, there was a gradual increase which peaked in 1984 with 10 publications. In 1985, the output of publications dropped. It subsequently increased during 1986 to 1990. In 1991, there was a large decrease again.

- Al, Ani, F. K.
- Al, Samarrae S. A. G.
- Al, Azzawi, H. T.
- Al, Rawi, Z. S.
- Hassan, F. K.

8. Main Authors

Annex D contains the bibliographic information of the publications from the College of Medicine and the authors of the publications. Box 8 lists the main authors of publications from the College of Medicine. These authors have published 4 or more publications.

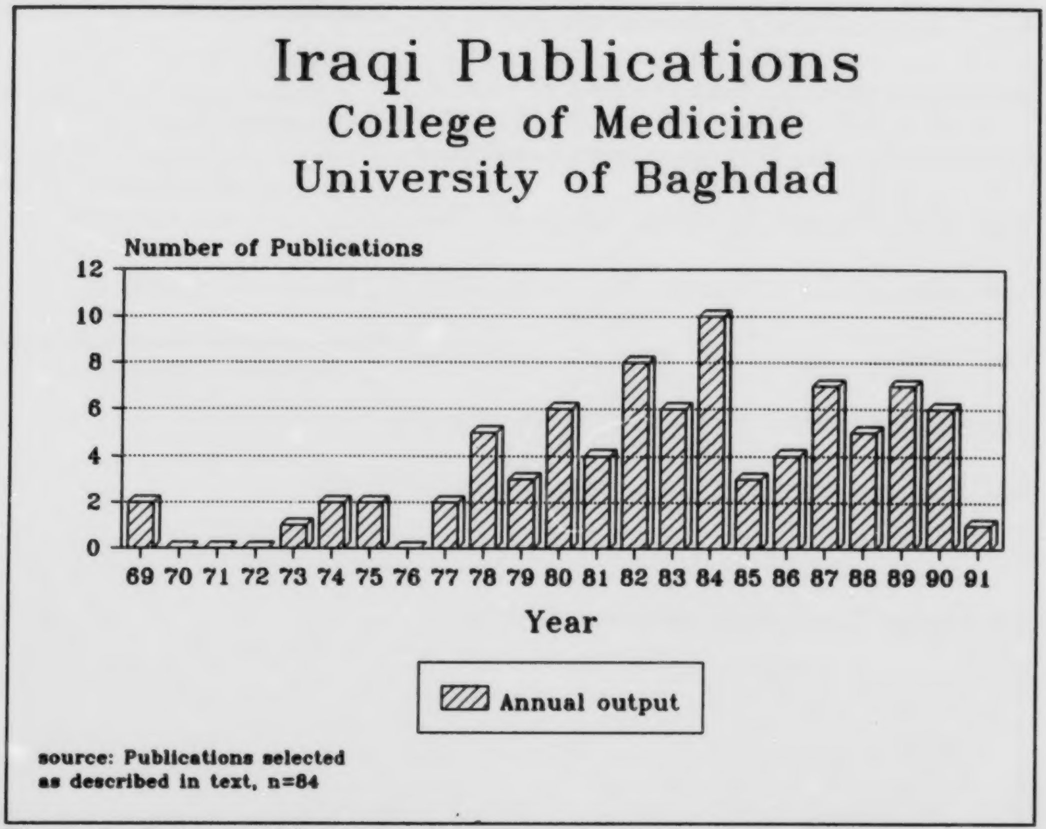


Figure 5. College of Medicine

Box 9 lists the research priorities of publications from the College of Medicine. These include surveys of endemic diseases in Iraq and potential treatments. From the published research, this facility does not appear to have extensive facilities for experimental work on the scale of the Nuclear Research Institute or the Biological Research Centre.

Toxins of Pseudomonas aeruginosa
Brucella abortus
Brucellosis
Clostridium perfringens Type A
Vibrio cholerae Toxin
Salmonella typhimurium
Tubocurarine
Epidemiology of Communicable Diseases

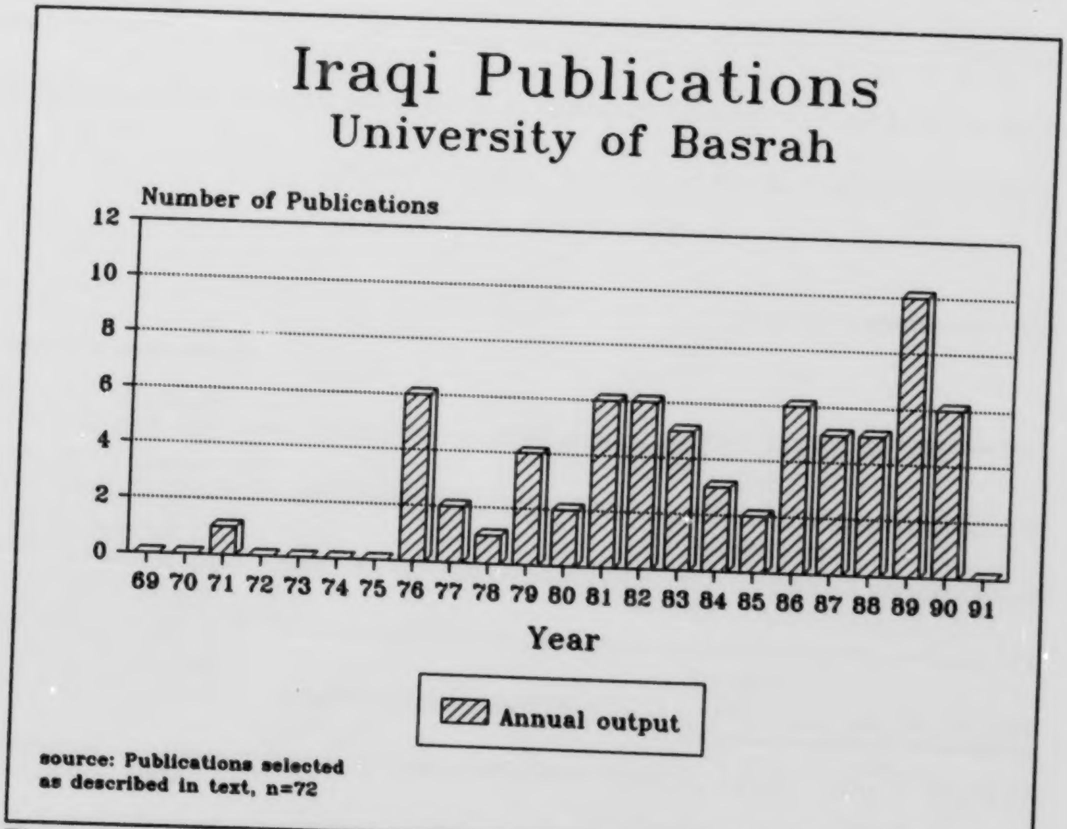
9. Research Priorities

3.6 University of Basrah

Abdullah, S. K.
Ajmal, M.
Al, Bader S. M.
Al, Rashidi R. K.
Al, Saadi H. A.
Al, Salim N. K.
Ismail, A. L. S
Muhsin, T. M.
Nafie, E.K.
Rattan, S. S.
Sarker, A. L.

10. Main Authors

The Department of Biology, College of Science at University of Basrah published 72 papers on research subjects selected by this study. Box 10 lists the main authors from this department. Figure 6 shows the time course of publications from the Department of Biology. There were few publications before 1975. Starting in 1976, more research was published.



source: Publications selected as described in text, n=72

Figure 6. Department of Biology, Basrah

Crimean congo hemorrhagic virus
Fusarium oxysporum
Clostridium tetani
Coxiella burnetii

11. Research Priorities

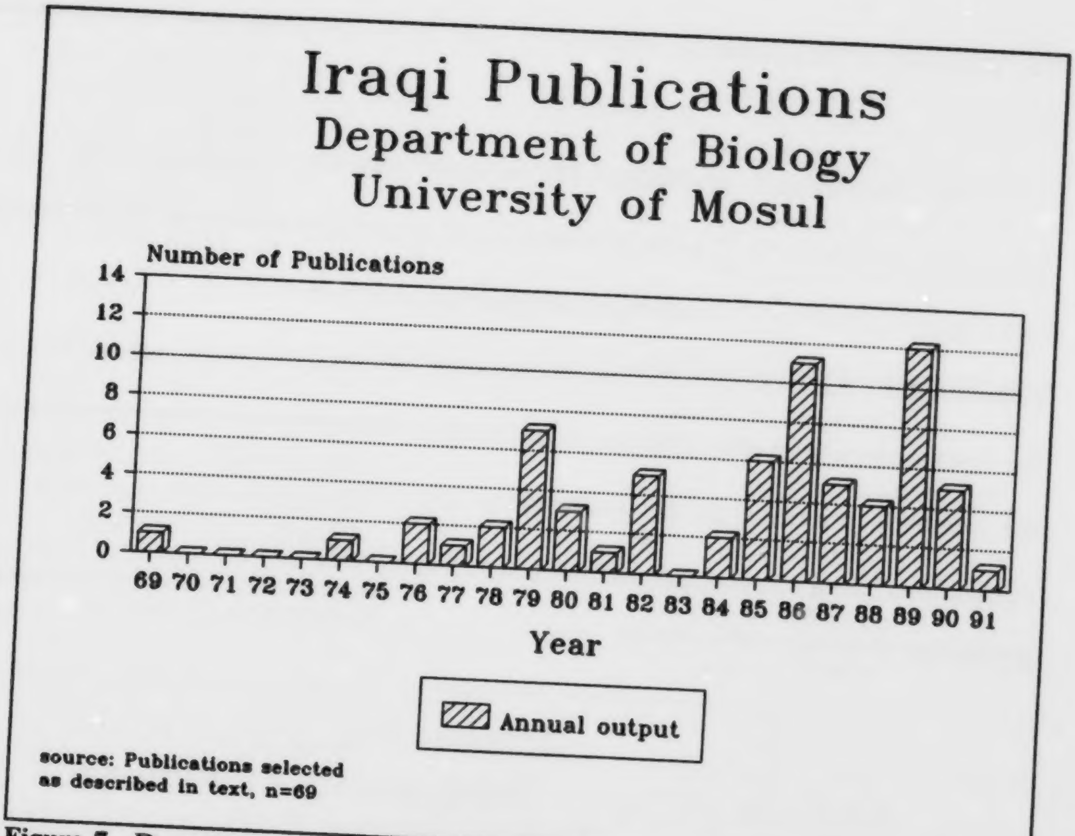
Annex E contains the bibliographic citations of these publications. It also lists all authors listed on the publications. Box 11 lists the research priorities of publications from the Department of Biology in Basrah. These studies included, epidemiological surveys of Q-fever, tetanus mortality and the Crimean-congo haemorrhagic virus in Iraq. Work with this virus usually requires high level biosafety precautions. The nature of the research reported in the studies makes it appear that the manipulations do not require high-level containment facilities. It is not clear whether such facilities were or were not available; or whether the types of research, where a high level of containment would be required, were not reported.

3.7 University of Mosul

Abbar, F. M.
Al, Chalabi K.
Al, Jebouri M. M.
Al, Khayat B. H. A.
Al, Khayat, T. M. N.
Al, Rajab, W. J.
Khalaf, S. H.
Mohammad, A. M. S.
Rashan, L. J.
Tahir, M.

12. Main Authors

The Department of Biology of the College of Science at the University of Mosul published 69 papers selected by this study. Annex F contains the bibliographic citations of these publications. It also lists all authors listed on the publications. Box 12 lists the main authors from the Department of Biology in Mosul. Figure 7 shows the pattern of publications from the Department Mosul. It shows great fluctuations from a peak in 1979 to no publications in 1983.



source: Publications selected as described in text, n=69

Figure 7. Department of Biology

Box 13 lists the research priorities of publications from the Department of Biology in Mosul. Anthrax and botulinum toxin A were each the subject of a single research paper from this laboratory. This was the only time these two agents were detected by this study in any Iraqi publications. The anthrax reference described the death of a person from the disease and the isolation of the causative bacterium. The botulinum toxin reference was from 1984, and dealt with contaminated food.

Influenza A Virus
Clostridium perfringens
Mycotoxins
Pseudomonas aeruginosa
Food Microbiology
Scorpion venom
Tetanus

13. Research Priorities

3.8 University of Sulaymaniyah

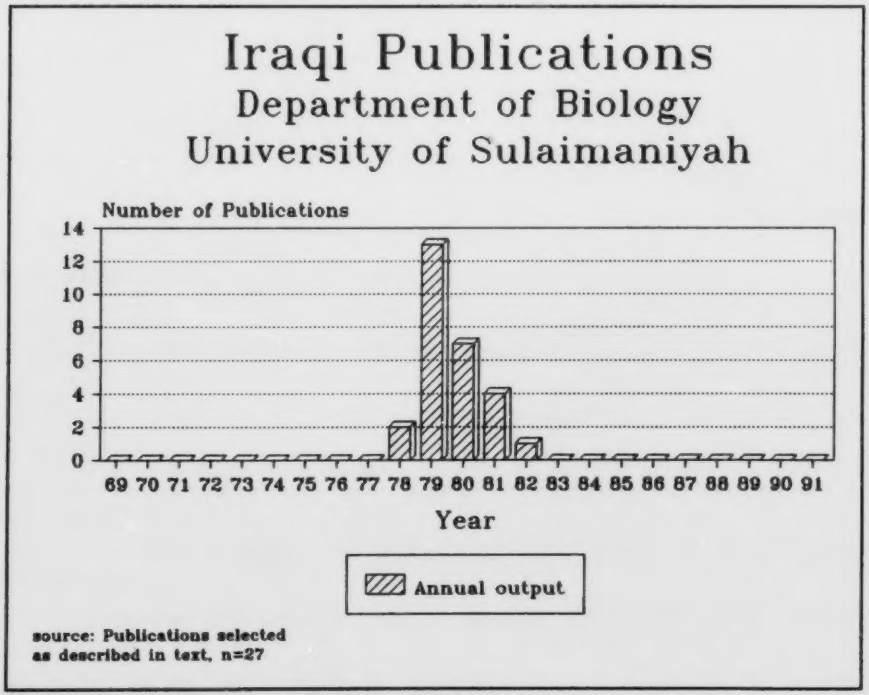
The Department of Biology at the University of Sulaymaniyah published 27 papers between 1978 and 1982 (see Figure 8) dealing with industrial microbiology and food contamination. Annex G contains the bibliographic citations and list of authors. Box 14 lists the main authors from this department. Box 15 lists the research priorities in the publications. No publications have been found from this department since 1983.

Armaghani, F. A. S.
Damirdagh, I. S.
El, Sawy M.
Maulood, B. K.

14. Main Authors

Disinfectants and Sterilization
Escherichia coli endotoxin
Industrial Microbiology

15. Research Priorities



source: Publications selected as described in text, n=27

Figure 8. University of Sulaymaniyah

3.9 Department of Microbiology, University of Baghdad

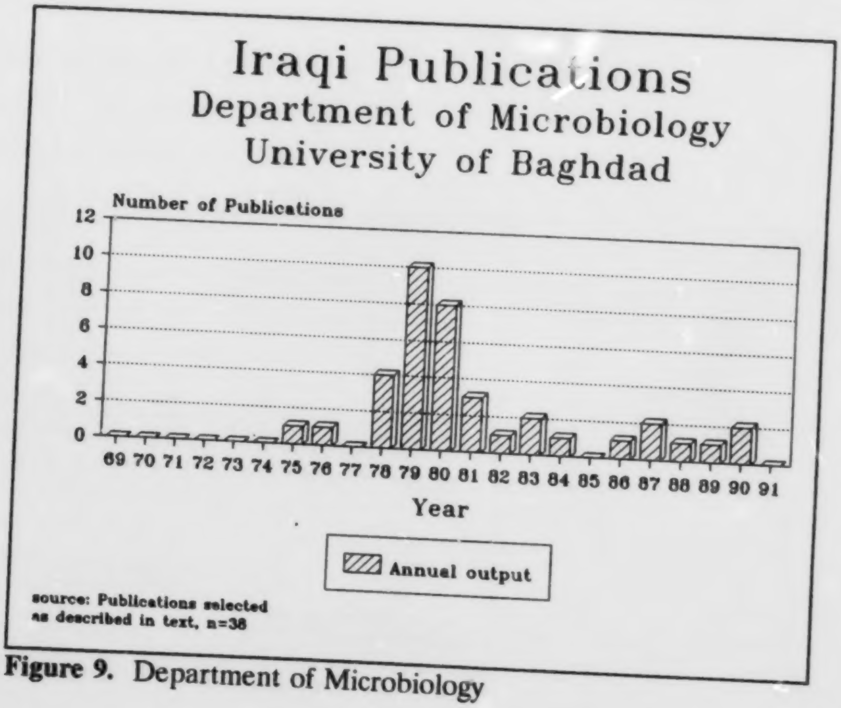
The Department of Microbiology at the University of Baghdad published 38 papers during the time period of this study (see Figure 9 for the time course). Most of the research was published between 1978 and 1981. Box 16 lists the main authors of this work. Annex H contains the bibliographic citations of the publications and the author list. Box 17 list the research priorities which include the Crimean-congo hemorrhagic virus and the tetanus toxoid. This work included one of the few publications from Iraq related to neurotoxins.

Al, Falluji M. M.
Al, Rawas A. Y.
Al, Sheikhly F.
Falluji, M. M. A.
Tantawi, H. H.

16. Main Authors

Infectious diseases
Hepatitis B Virus
Crimean-congo hemorrhagic fever virus
Tetanus Toxoid
Vaccinia Virus

17. Research Priorities



source: Publications selected as described in text, n=38

Figure 9. Department of Microbiology

3.10 Department of Pharmacology, University of Baghdad

The Department of Pharmacology at the University of Baghdad published 35 papers. Annex I lists the publications and authors involved. Box 18 lists the main authors that have published on these topics. Box 19 lists the research priorities from this laboratory. A topic of research that stands out is a series of papers examining the nasal absorption of the bioregulator enkephalin. This research appears to involve çollaboration with a Japanese author. Figure 9 shows the time course of publications from this laboratory.

Al, Jibouri L. M.
Al, Jubouri H. H.
Borazan, H. N.
Jawad, F. H.

18. Main Authors

Endotoxin
Enkephalin Nasal Absorption
Insulin
Pharmacology
Pharmaceuticals

19. Research Priorities

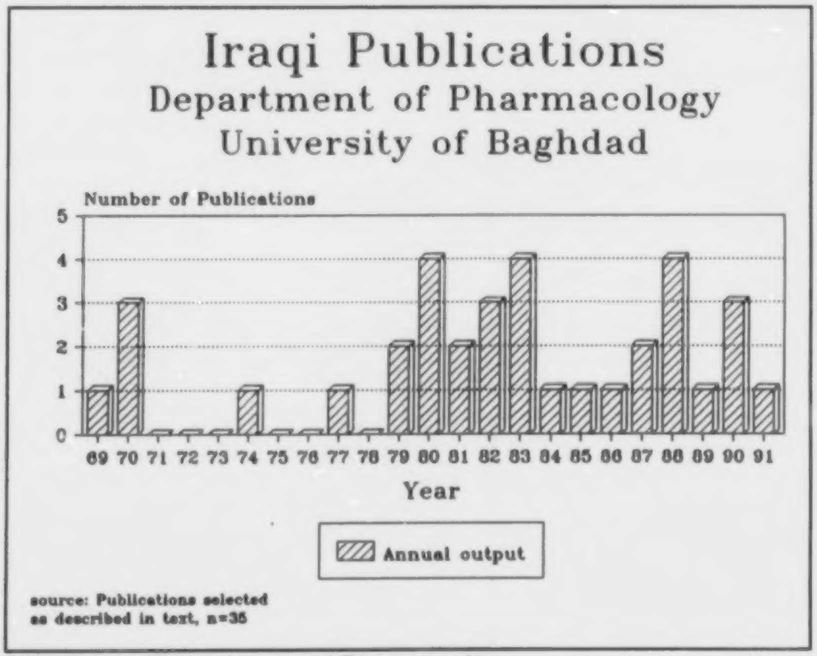


Figure 10. Department of Pharmacology

3.11 University of Salahaddin

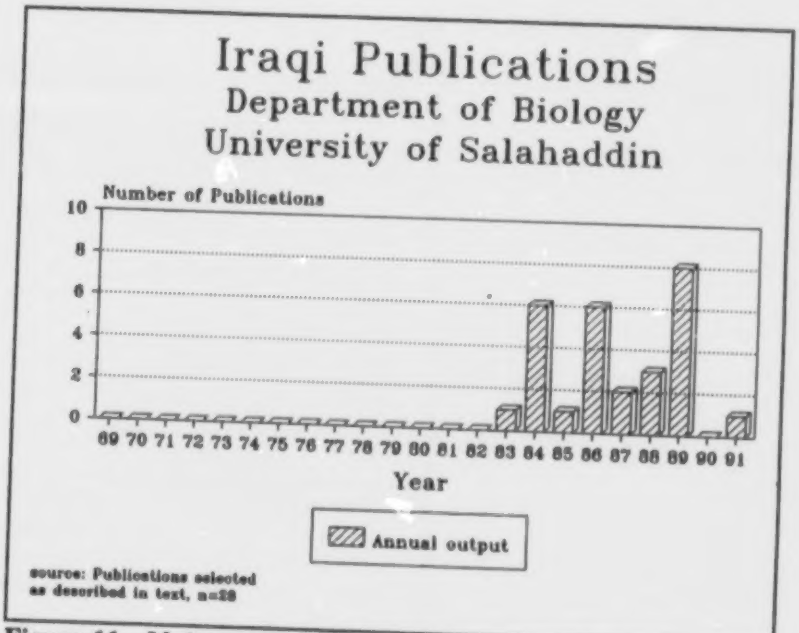
The Department of Biology in the College of Science at the University of Salahaddin is located in the city Irbil (also spelled Erbil). It published 28 papers after 1982 (see Figure 11). Publications decreased after 1989. Annex J lists these papers and the authors. Box 20 gives the main authors. Box 21 lists the research priorities.

Molan, A. L.
Mumma, R. O.
Rafiq, S. N.
Rashid, K. A.
Sarhan, A. R. T.

20. Main Authors

Bacterial infections
Fusarium oxysporum
Mycotoxins

21. Research Priorities



source: Publications selected as described in text, n=28

Figure 11. University of Salahaddin

3.12 Genetic Engineering and Biotechnology Research Centre, Baghdad

The Genetic Engineering and Biotechnology Research Centre of the Scientific Research Council is located in Baghdad. It was the only Iraqi research centre which published research dealing with recombinant DNA. Annex K lists the papers and authors from this Centre. Box 22 lists the main authors. Box 23 lists the research priorities. Figure 12 shows the time course of publications from this research centre.

Abdul, Nour B. A.
Abdulla, S. M.
Al, Attiyah S. S.
Al, Bassam R.
Al, Doori Z.
Al, Tai A. M.
Al, Zaag A.
Al, Bassam, R.
Ewad, M. J. S.

22. Main Authors

Recombinant DNA
Bacteria

23. Research Priorities

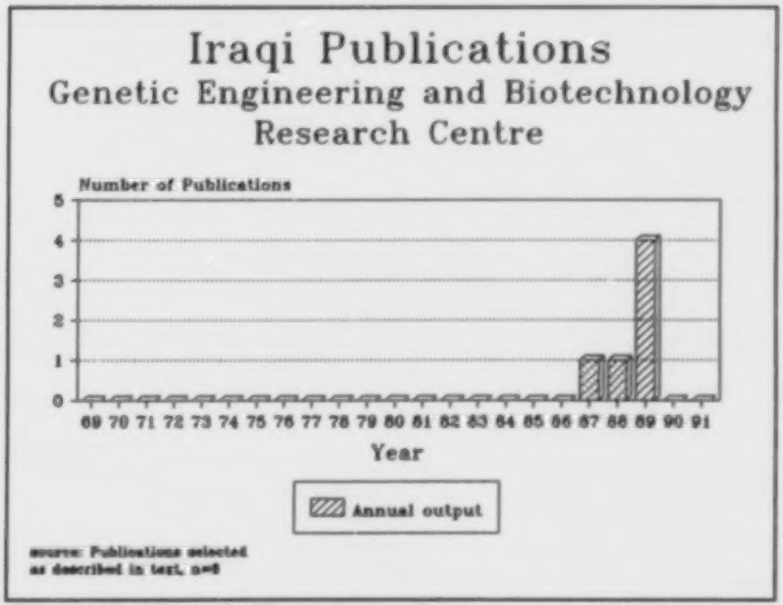


Figure 12. Genetic Engineering Centre

3.13 State Company for Drug Industries, Samarra

The Research laboratory of the State Company for Drug Industries is located in Samarra. It published 4 papers in the scientific literature between 1976 and 1988. Annex L lists these papers and their authors. The research described in these papers concerns the search for new drugs and their formulations. Some of this research was published in East Germany and the co-authors of the publications were East Germans.

3.14 Other Institutes and Laboratories

Annex M contains the bibliographic citations of research publications from other institutes and laboratories that published biological and toxin research from Iraq. This includes research laboratories with few publications, as well as publications in which no institutional affiliation was given.

4.0 CONCLUDING REMARKS

4.1 Sites of Biological and Toxin Research

This study examined the open scientific literature to determine the patterns, locations and apparent nature of Iraqi biological and toxin research. In regard to these objectives, the following observations can be made.

Judging from the published research, there seemed to be a significant difference between the nature and quality of research at Iraqi government laboratories and the laboratories located at universities. The quality of the experimental work was consistently higher at the government research facilities. In the case of Iraq, it could be argued that due to the tight control by the socialist government, universities may not have the same independence as universities in Western countries. When examining the range of experimental procedures, equipment and publication output per institute, the government laboratories appear to be superior.

The main sites of research were the Biological Research Centre of the Scientific Research Council, in Baghdad; and the Nuclear Research Institute of the Atomic Energy Commission, in Tuwaitha. Judging by the published research, the most sophisticated work has been done in these two laboratories. Also notable for the advanced level of research was the Genetic Engineering and Biotechnology Research Centre, of the Scientific Research Council, located in Baghdad. However, this Institute has had a much smaller output of published papers, with only 6 publications published during the years 1987 to 1989. It was only during these years that publications were found. It is possible that this institute is quite new. The Genetic Engineering and Biotechnology Research Centre was the only Iraqi laboratory that published research using recombinant DNA techniques for bacterial biochemistry.

The Research laboratory of the State Company for Drug Industries was located in Samarra. Judging by the few publications from this laboratory, it appears that there was co-operation with East German researchers before 1983. It is worth noting this laboratory is located in close proximity to the Iraqi State Company for Pesticide Production. It has been widely reported that the latter Iraqi company was involved with the procurement of precursors for chemical warfare agents. In the same way, the extent of biological research and especially its increase at the Nuclear Research Institute at Tuwaitha may be of interest. While it is not unusual for a nuclear facility to conduct biological research, it may be significant that the biological research at the Iraqi Atomic Energy Commission at Tuwaitha is one of the leading biological research laboratories in Iraq.

4.2 Patterns of Publications

The major trend in Iraqi biological research that was repeated in many of the laboratories described in this study can be described as follows. Initially, there was low number of publications which showed a major increase from 1979 to 1981. After this peak of publications, there was a decrease during 1983 to 1985. Following this, there was another large increase.

In order to have an increase in research output, significant resources must be committed. Laboratories must be built or equipped, and researchers must be employed or re-assigned. Once new laboratories are set-up, research must be initiated and completed, and then published. This results in a significant lag between a change in research priorities and that change becoming evident in publications in the open literature. Therefore, the increased publications first observed around 1979, may reflect a change in research priorities decided upon around 1975.

The sudden decreases seen in publications may also reflect changes in research priorities, shortages due to the war effort, or censorship.

4.3 Gaps in the Publications

In some cases, when examining the open scientific literature, **what is not found** may also be of interest. The following section will examine several topics that appeared to be under-represented or totally lacking in the Iraqi scientific literature.

Two potential warfare agents that are often mentioned in relation to concerns about biological and toxin warfare are *Bacillus anthracis* and the botulinum neurotoxin A. These two agents, respectively, cause anthrax and botulism. Anthrax causes fever, shock and, if inhaled, has a mortality rate of between 80 to 100 percent. Botulism, often fatal, causes vomiting, convulsions, and paralysis. Only a single paper on each of anthrax and botulism were found from Iraq in the research publications from 1969 to 1991. (As mentioned in the Introduction, Iraq has now reported that it has conducted research on *Bacillus anthracis* and the botulinum neurotoxin A for military purposes.)

There are several possible explanations to this finding. For one, there may be no research conducted on anthrax in Iraq. This is unlikely since anthrax is a potential health hazard in Iraq (see Annex F, publication 11), quite apart from any research conducted for military purposes. Therefore, another possible explanation is that anthrax is deliberately not mentioned in any research coming from Iraq.

The same argument can be made for two other potential biological warfare agents. They are the bacterium *Francisella tularensis*, which causes tularemia, and the West Nile virus. In both cases, it appears that Iraq has acquired strains of these microorganisms as mentioned in the Introduction to this paper, but has not published any research in the open scientific literature.

The American Type Culture Collection (ATCC) has one of the world's leading collection of microorganism, and acts as a clearinghouse for institutions all over the world. It manages 1,000 different strains of microorganisms. The ATCC sells approximately 130,000 cultures annually and ships orders to sixty nations. The ATCC is reported to have sent about seventeen shipments over the past five years of attenuated strains of various toxins and bacteria, including the bacteria which causes tularemia, to Iraq's Atomic Energy Commission. The U.S. Centres for Disease Control is reported to have shipped viruses to researchers in Iraq, and handled them informally, with no records kept of the transfers.

One microorganism requested by, and supplied to, an Iraqi researcher in Basrah was a strain of West Nile virus (see The New Republic, Volume 204, issue 5, page 18). The virus has been the subject of concern as a potential biological warfare agent. It should be noted that this study identified a laboratory in Basrah that studied the Crimean-congo hemorrhagic virus (see Annex E, publications 34 and 35) but did not publish on the West Nile virus. These two viruses, as well as the Yellow Fever virus, fall within the same class known as "Arbovirus".

In 1989, several newspaper reports stated that the Iraqis were conducting research in biological warfare at Salman Pak. Three potential biological warfare agents mentioned most frequently in association with this centre were the bacterium which causes anthrax, botulinum toxin and the yellow fever virus. The Iraqis originally claimed that the research at Salman Pak was concerned with health matters related to food contamination. (They later reported to a United Nations inspection team that they had conducted research at Salman Pak between 1986 and 1990 for military purposes.) This study found no publications at all from Salman Pak.

One important early warning indicator of possible diversion of biological materials would be major government biological facilities that do not publish in the open literature. Therefore, unless the Salman Pak facility has published without corresponding identification, or has published on topics not related to its main area of interest, there is no indication that it has published any of its research in the open scientific literature.

ANNEX A

Major Iraqi Laboratories Publishing Biological Research

Biological Research Centre, Scientific Research Council, Baghdad

Nuclear Research Institute, Atomic Energy Commission, Tuwaitha

College of Medicine, University of Baghdad

Department of Biology, University of Basrah

Department of Biology, University of Mosul

Department of Microbiology, University of Baghdad

Department of Pharmacology, University of Baghdad

Department of Biology, University of Sulaymaniyah

Department of Biology, University of Salahaddin

Genetic Engineering and Biotechnology Research Centre, Baghdad

Research Laboratory, State Company for Drug Industries, Samarra

The following Annexes contain an alphabetical bibliography and an author list of the publications of the above-mentioned Iraqi research laboratories.

ANNEX B

Biological Research Centre

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   Note: En. (English) [This refers to the language that the publication is written in.]

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   Note: DIALOG CA Search file 399 English.

3. Abdul, Nour B. A.; Al, Ani R. A.; Al, Khaffaji H. M. Bacteriological studies on local soft cheese in baghdad. Bull biol res cent (baghdad); 1976; 7: 71-82.
   Note: En.

4. Abdul, Nour B. A.; Al, Dulaimi A. K. N.; Al, Saadi A. I. S.; Al, Attiyah S. S.; Al, Khafaji H. M. Causes of cow mastitis in baghdad iraq area. Bull biol res cent (baghdad); 1978; 10: 1978.
   Note: En.

5. Abdul, Nour B. A.; Ibrahim, M. A. K.; Mahdi, A. A.; Al, Ani M. S. Leakage of intracellular components from candida-parapsilosis ii. effect of temperature. J biol sci res; 1987; 18(1): 41-48.
   Note: En.

6. Al, Bassam R.; Al, Jumaily W.; Rawi, A. A.; Suffi, F. A. Evaluation of methods of extraction and partial characterization of cell wall carbohydrates of brewer's yeast strain saccharomyces-cerevisiae. Mircen j appl microbiol biotechnol; 1986; 2(3): 383-388.
   Note: En.

7. Al, Bassam R.; Mohammed, A. K. I.; Awatif, A. R.; Feham, A. J. S.; Neda, A. F. K. The chemical composition of the cell wall of schizosaccharomyces-pombe wild type and cycloheximide resistant mutants. J biol sci res; 1986; 17(2): 267-274.
   Note: En.

8. Al, Doori Z.; Clor, A.; Ali, N. Characterization of piq-5 plasmid originating from klebsiella-pneumoniae. World j microbiol biotechnol; 1990; 6(2): 117-120.
   Note: En.

9. Al, Doori Z. A.; Kaddouri, M.; Clor, A.; Naom, I.; Al, Naimi I.; Sadek, A. K.; Al, Ani Z.; Ali, N.; Murad, K. Multiple antibiotic resistance of enteropathogenic escherichia-coli from baghdad. J biol sci res; 1986; 17(3): 195-206.
Note: En.

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Note: En.

11. Al, Ghazali M. R.; Al, Azawi S. K. Listeria-monocytogenes contamination of crops grown on soil treated with sewage sludge cake. J appl bacteriol; 1990; 69(5): 642-647.
Note: En.

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Note: En.

13. Al, Ghzali M. R.; Jazrawi, S. F.; Al, Doori Z. A. Antibiotic resistance among pollution indicator bacteria isolated from al-khair river baghdad iraq. Water res; 1988; 22(5): 641-644.
Note: En.

14. Al, Jumaily W. T.; Abdul, Latif H. M. Total viable and direct counts of bacterial population in the rumen of awassi sheep. J biol sci res; 1988; 19(3): 587-598.
Note: En.

15. Al, Jumaily W. T.; Al, Atar M. A.; Al, Tae A. R.; Mansour, A. D.; Jiad, J. H.; Abdul, Latif H. The incidence of salmonellae and serological evidence of newcastle disease in some wild birds from baghdad area iraq. J biol sci res; 1989; 20(2): 213-220.
Note: En.

16. Al, Jumaily W. T.; Caldwell, D. R. Some effects of glucose and ammonia on protein synthesis by rumen bacteria. Mircen j appl microbiol biotechnol; 1986; 2(3): 389-398.
Note: En.

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Note: En.

18. Al, Shahwani M. F.; Al, Rawi E. H. Bacterial extracellular material from brewery wastewater for raw water treatment. Biol wastes; 1989; 28(4): 271-276.
Note: En.

19. Al, Shahwani M. F.; Al, Rawi E. H. Clarity performance variables of polluted water. Water air soil pollut; 1988; 39(1-2): 113-122.
Note: En.

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Note: En.

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Note: En.

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Note: En.

23. Al, Shahwani M. F.; Jazrawi, S. F.; Al, Rawi E. H. Analysis of flocculation by actinomadura-sp. Biol wastes; 1988; 26(3): 159-166.
Note: En.

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Note: En.

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Note: En.

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Note: En.

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Note: En.

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ANNEX C

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Annex G4

ANNEX H

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